TECHNICAL report

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Air Conditioner Requirements Validation Review of the Divarty Computer Group of the Fire Direction Center, Artillery (OL-48B/GSG10(V)), or TACFIRE

by
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Report Date
May 1992

Belvoir RD&E Center

United States Army
Belvoir Research, Development and Engineering Center
Fort Belvoir, Virginia 22060-5606

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This report assesses the tactical electric power and cooling requirements of the TACFIRE DIVARTY Computer Group, AN/GSG-10(V), for the "Air Conditioner Requirements Review Program."

14. SUBJECT TERMS

System Assessment Model (SAM)
Environmental Control Unit (ECU)

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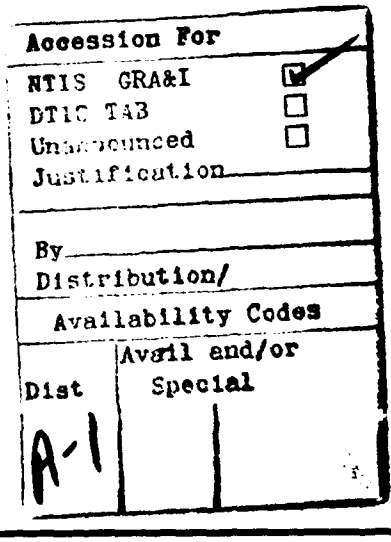

Section I

Background

The U. S. Army's Troop Support Command (TROSCOM) and Training and Doctrine Command (TRADOC) initiated the "Air Conditioner Requirements Review Program" to establish requirements for a new generation of environmental control equipment. TRADOC's Ordnance School; TROSCOM's Special Programs Management Office; and Belvoir Research, Development and Engineering Center (BRDEC) Systems Assessment Team were the program's primary participants. The Systems Assessment Team was directed to assess the electric power and cooling requirements of selected Army systems. To assist in this effort, a Special Sample Data Collection (SSDC) Project was established under the auspices of the TROSCOM Sample Data Collection Program. The SSDC Project inventories each system, paves the way for the assessment, and conducts operator interviews regarding the effectiveness of existing electric power and cooling equipment. Systems to be assessed include: DAS-3, MSE, TACMIS, FAADS, SICPS, and Patriot.

Section II

Approach

It is necessary to account for electrical power demand when determining the cooling load of a system. This process involves three steps:

First, all power consuming equipment in the system's shelter must be inventoried. This includes collecting the manufacturer's nameplate data and inspecting manuals for each item.

Second, the system's power consumption must be measured while equipment items, groups, and the entire system are powered-up and powered-down. From this data, the power demand of each piece of equipment and a predicted maximum system power demand can be derived. This technique includes power conditioner losses with the supported equipment's power demand.

Finally, the shelter's thermal characteristics and personnel and tactical requirements must be entered into the Shelter Systems Assessment Model (SAM). The computer model can then determine cooling loads and Environmental Control Unit (ECU) suitability under hypothetical ambient conditions. When test conditions allow, the ECU needs should be validated using temperature data taken during the test and by interviewing experienced system operators.

Section III

System Description

TACFIRE supports the artillery mission by:

- Collecting target information from forward observers.
- Calculating optimum projectile type(s) and trajectory(ies) using topological, weather, and strategic information.
- Transmitting information to decision makers and artillery operators.

The TACFIRE DIVARTY Computer Group, Fire Direction Center, Artillery, Model OL-48B, AN/GSG-10(V) (Line Item Number F55750, National Stock Number 7010-01-017-7040) is housed in an S-280 shelter mounted on a 5 ton truck. Field power is provided by a 15 kW, 400 Hz trailer-mounted generator set (Line Item Number G36074). Cooling is provided by an 18,000 BTUH horizontal air conditioner (Line Item Number A24575).

TACFIRE's electronic equipment includes communications, data recording and processing, and graphical mapping capabilities (see page 4 of Appendix). Three soldiers operate the system.

Section IV

Discussion

An inventory of TACFIRE was performed and each piece of power consuming equipment was listed as a column heading on the Power Measurement Load Configuration form (see Figure 2 of Appendix). This form documents the switch position for each equipment item at each step of the test sequence. The test began with all equipment except the heater on or in stand-by mode. The test team took power consumption readings at the power source while operators switched off equipment in sequence. The power readings were entered in the Power Generator Performance form (see Figure 3 of Appendix). This form records the load on each phase of the generator for each step in the test sequence.

The power consumed by each item, including associated power conditioning losses (see Table 1), is derived from the change in total power as the item is switched off. The power consumption data listed on Table 1 is grouped into several subcategories.

The first category, "Total Measured Power Demand in Operational Mode," refers to equipment that was tested at its full operational capacity. The second category, "Measured Power Demand in Stand-By Mode," refers to equipment for which test conditions prevented maximum load operation. For example, a plotter cannot operate unless a job is available to run. Those subtotals are then added to achieve "Total Measured Power Demand Internal Load," which is the electric power which the ECU capacity must compensate for to maintain the desired internal temperature. The final total, "Total Estimated Generator Load," includes the electric load which does not contribute to the cooling requirement.

Power consuming items and their respective power demand were used as input for several runs of the SAM (see Table 2 on page 6). Internal temperature was selected to satisfy Human Engineering MIL-STD-1472 considerations (90°F). Internal humidity was limited to 60%. Desert conditions (environment 1, AR 70-38), tropic conditions (environment 4), and equipment power use of 0 through 10 kW were analyzed. Assumptions used in the computer analysis are found in the figure on page 7.

Table 1. TACFIRE Equipment Power Demands

Nomenclature	Model Number	Power Demand (watts)	
Power Converter Group	OV-41/GSG-10(V)	256	
Lighting, Overhead	DC	155	
Total Measured Power Demand in Operational Mode		***411***	
Artillery Control Console	OJ-70/GSG	300	*
Converter, Data	CV-2863	245	*
Modular Test Set	AN/GSM 208	78	*
Monitor, Remote Communications***	MX9842/G	290	*
Communications Control Assembly***	C-9901/G	(Total)	
Radio Set	AN/VRC-46	55	*
Electronic Line Printer	RO-344	55	*
Keying Generator	KG-31	344	*
Central Processor	CP-1822	77	*
Total Measured Power Demand In Stand-By Mode		***1444***	*
Total Measured Power Demand Internal Load		***1855***	
Digital Plotter, Map and Display Control Unit	PT/493/G	600	**
Decontamination Unit	M56	500	**
Total Internal Load, Estimated + Measured		***2950***	
Environmental Control Unit	Cooling	5400	
Horizontal, 18 KBTUH	Heating	3970	
Maximum ECU Power Demand as Measured		***5400***	
Total Generator Load as Measured		***7250***	
Total Estimated Generator Load		***8350***	

* Operated in stand-by mode

** Equipment not measurable on site, estimated values

***Equipment powered through a common switch was turned on and off simultaneously. Therefore, only total power power consumption could be calculated.

Table 2. System Assessment Model (SAM) Data

SHELTER SYSTEM ASSESSMENT MODEL
HVAC, POWER, AND WEIGHT REQUIREMENTS

Run Parameters	Calculation Details	Totals
Run Config. Environ. 1 Tacfire ENV1 Structure: S-280 Weight: 1400.0 lbs Other Settings AC Util. Conv. In. No CBR Total CFM: 60.0 Min. Interior Temp. 50. (°F) Max. Interior Temp. 90. (°F)	BTU/Equip. : 3413. (>0 for AC, /Shelter: 6998. <0 for Heat) /Sensible & latent heat due to ventilation and personnel: 2719. KW/ a) Heat: 0.00 b) AC: 4.48 c) Equip: 1.00 d) Max(Heat,AC): e) Max(MaxHeat,MaxAC,MaxEqp): Note: "b" accounts for the highest individual power consumer regardless of usage rate and includes the startup factor. Personnel Wt: lbs AC Weight: lbs Equip Wt: lbs Generator Wt: lbs	BTU/hr 13130.0 Adjusted Power (KW) [Max(c+d,e)] Total Wt. Incl. Struc. (LBS)

CONFIGURATION DESCRIPTIONS

CONFIGURATION: Tacfire

Config description: -0-
It is housed in a: S-280

PERSONNEL LOAD/AC

QTY	SENSIBLE LOAD (BTU/hr)	LATENT LOAD (BTU/hr)	VENTILATION (CFM/hr)	WEIGHT/PERSON (lb)
3	315.00	325.00	20	267

ENVIRONMENT CHARACTERISTICS

ENVIRONMENT NAME	TEMPERATURE OUTSIDE (°F)	HUMIDITY OUTSIDE (%)	WIND SPEED (mph)	SOLAR LOAD (BTU/HR/ft²)	GROUND TEMPERATURE (°F)
ENV4	95.0	100.0	8.9	307.0	130.0
ENV1	120.0	5.0	8.9	231.0	145.0

DATA FOR STRUCTURES

NAME		TOP	SIDE	END	BOTTOM
S-280	Surface area (ft²):	90.00	180.00	112.50	90.00
	U-factor (BTU/hr/ft²/°F):	0.28	0.28	0.28	0.28
	Solar Absorb.(BTU/hr/ft²):	0.70	0.70	0.70	0.70
	Angle with horizontal:	0.00	90.00	90.00	180.00
	Area of Uninsulated Penetration by Conduits(ft²):	0.00	0.00	0.00	0.00

Weight (lbs): 1400.0 Heat Capacitance (BTU/Lb/°F): 1.

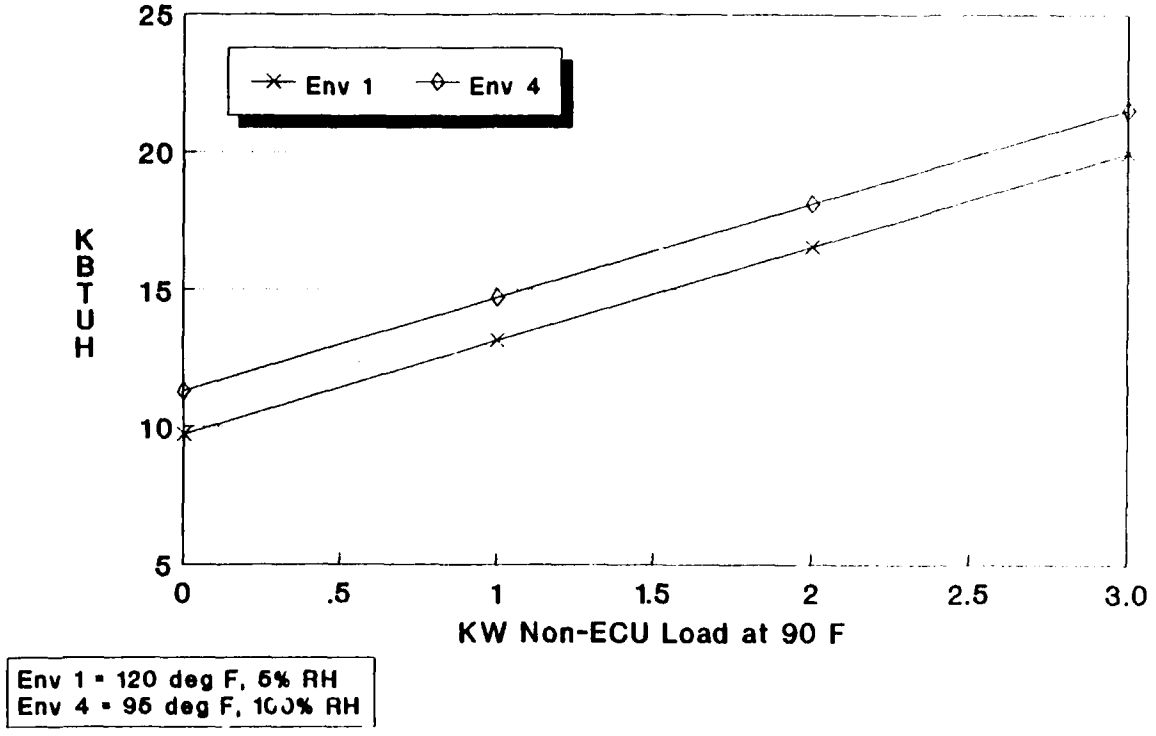

Figure of TACFIRE Cooling Requirements, 90°F Internal

Section V
Findings

TACFIRE power demand, with all available equipment operating, measured 7.25 kW, including 5.4 kW for ECUs and 1.85 kW for equipment. In this configuration, a 10 kW generator set will support the system. However, previous studies show that the TACFIRE system is sensitive to the voltage drop caused by the environmental control unit starting up and cycling. Therefore, the larger 15 kW generator set is appropriate for the system. The 18,000 BTUH air conditioner provides the necessary cooling for TACFIRE's electronic equipment.

There is an effort underway at Fort Belvoir to develop a new family of Multiple Power Input (MPI) ECUs. The power drawn by the MPI ECUs will "ramp up," significantly reducing the power line transients caused by the current family of ECUs. TACFIRE may reduce its logistical burden by using an MPI ECU and a 10 kW generator instead of the current 15 kW generator.

Appendix

COBRO
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SR90-156

November 8,1990

Special Report

Air Conditioner Requirements Review
Power Consuming Equipment Inventory
Fire Direction Center, Artillery

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AIR CONDITIONER REQUIREMENTS REVIEW

TACFIRE ASSESSMENT

INTRODUCTION

This special report on field data collected has been prepared to provide Belvoir Research, Development and Engineering (RD & E) Center's Systems Assessment Team selected information about the TACFIRE system, an Army equipment designated by U.S. Army Ordnance Center and School (Letter, ATSL-CD-MS, Subject: Air Conditioner Requirements Review, dated 19 September 1990) as a system best suited to provide input to an air conditioner requirements analysis.

PROGRAM OVERVIEW

The collected information from each of nine systems will be summarized by the Systems Assessment Team in a concise, meaningful form, and conveyed to the Training and Doctrine Command (TRADOC) Air Conditioner Requirements Review (ACRR) Team at the U. S. Army Ordnance Center and School for consideration as the team addresses and recommends attributes for a new standard family of tactical air conditioners.

The specified systems are:

TACFIRE	-Direction Center, Artillery
FAADS	-Forward Area Air Defense System
JTIDS	-Joint Tactical Information -Distribution System
SICPS	-Standardized Integrated Command Post -System
MSE	-Mobile Subscriber System
PATRIOT	-Air Defense Missile System
DAS3	-Decentralized Automated Service -Support System
HAWK	-Air Defense Missile System
TACMIS	-CTACS-II (Corps/Theater ADP Service -Center)

Coordination to gain access to the target systems is done at command levels. Local schedules and task interpretation at the owning unit is done by COBRO representatives on site.

DATA COLLECTION INFRASTRUCTURE

The data collection phase of the ACRR program utilizes Belvoir's Tactical Assessment of Power (TAP) Sample Data Collection (SDC) program. The TAP program was selected to support the ACRR program because all of the field data can be obtained in similar fashion and without adding additional people.

TAP is supported in the field using the contracted support infrastructure for SDC. COBRO Corporation provides the support to TAP and to ACRR through its offices at Fort Belvoir, Fort Bragg, Fort Hood, and others, depending upon where the target systems can be located.

DATA OBJECTIVES

The collection is focussed on the equipment listed under Program Overview. The purpose is to develop detailed data on tactical power consumers, tactical shelters, tactical air conditioners mounted on the tactical shelters, shelterized system crew staffing, system environmental capability, system operating profiles, and crew training and experience.

COLLECTION METHODOLOGY

Data are collected on site by a team of people organized to perform a subsystem inventory, conduct a controlled, power-up procedure, measure operating and environmental parameters, and debrief operators about their training on the system, their field experience with the system, and the system's operating modes.

The data collection field team consists of a Senior Technician and an Engineer from the Systems Assessment Team at Fort Belvoir. A Field Monitor from a COBRO Corporation field office and the COBRO Senior Technical Analyst for the COBRO TAP SDC Program at Fort Belvoir completes the team.

At the field site the team accomplishes the following:

Assistance of the system operator(s) is solicited to identify the separate power consuming subsystems/components of the system housed in the shelter. The inventory data are posted to the Power Using Inventory form (Figure 1).

The interrelationships and power supply lash-up is reviewed as a basis for developing a measurement test plan. Initially, the plan is tentative and can be sensitive to the unexpected. The plan is modified as necessary and is posted to the Power Measurement Load Configuration form (Figure 2) as a sequence of power-up events. Results are posted by input power phase (A, B, and D) to the Power Generator Performance Data form (Figure 3).

Notes about shelter size, trailer information, prime movers, generators, and air conditioners are taken. Operators and crew members are debriefed to gain insight to operating modes, operating conditions, training, and field experiences. Debriefings are based on the format presented in Figure 4.

The collection team reviews the information gathered and conducts an initial analysis to insure values of voltage, current, and wattage are available for each component; either measured directly or calculated from other measured values.

POWER ANALYSIS

Values recorded on the Power Generator Performance Data Form are verified by the Systems Assessment Team at Fort Belvoir using procedures calculated to establish the power values to be used later in Fort Belvoir's Shelter Systems Assessment Model (SAM).

SAM is exercised to determine cooling requirements to maintain Human Engineering habitability conditions (MIL-STD-1472) at various climate conditions.

TACFIRE DESCRIPTION

TACFIRE is an automated fire direction center used by field artillery organizations to plan, control, and direct friendly artillery fires. The center contains ruggedized computer and communications components in an S-280 tactical shelter. The shelter is carried on a 5-ton truck. The 5-ton truck tows a 15KW, diesel generator for 400HZ electrical power. TACFIRE may be located at DIVARTY and brigades, as well as artillery battalions. Mission requests and target information is typically received by digital link from the fire support element, forward observers, fire support teams (FIST), mortar and locating radars, and area air and ground surveillance systems.

TACFIRE POWER CONSUMING EQUIPMENT INVENTORY

The brigade TACFIRE assessed is identified as Fire Direction Center, Artillery, Line Item Number F55750, NSN 7010-01-017-7040, OL-48B/GSG-10(V). It is assigned to 5th Battalion, 8th Field Artillery Brigade at Fort Bragg, North Carolina. The shelter is environmentally controlled by one, front-mounted, 18,000 BTU air conditioner, model F 18H-4. The shelter is also equipped with a front-mounted, model M56 decontamination unit. Internal components are furnished 208VAC directly and 28 VDC indirectly via a power converter group. The subsystem components which make up the power consumers in TACFIRE are:

POWER CONSUMING EQUIPMENT

Code	Line Number	Nomenclature	Model	Stock Number
AD079	None	Group, Power Converter	OV-41	7010-01-042-0331
AD093	None	Display, Digital Plotter	PT/493	7025-01-043-0926
AD081	None	Unit, Magnetic Tape	C-10679	7035-01-042-5308
AD094	None	Processor, Central	P-1822	549500-10
AD074	None	Console, Arty Control	OJ-70/GSG	5895-01-043-0925
AD095	None	Generator, Keying	KG-31	None
AD096	H48904	Unit, Decontamination	M56	4240-00-237-0227
AK024	A24575	Conditioner, Air	F 18H-4	4120-00-411-3731
AD097	None	Monitor, Remote Commo	MX-9842/G	None
AD073	None	Printer, Electronic Line	RO-344	5985-01-044-1677
AM	Q53001	Set, Radio	AN/VRC-46	5820-00-223-7433
AD077	None	Assembly, Commo Control	C-9901/G	5895-01-042-9709
AD080	None	Converter, Data	CV-2863	5895-01-043-6388
AD090	None	Modular Test	AN/GSM-208	6625-01-044-1676
AA019	None	Light	DC	None

DEBRIEFING

A debriefing plan had not been approved for use at the time of the TACFIRE assessment.

SYSTEMS INVENTORY FORM

1. Control Number	2. Line Number	3. NSN	4. Nomenclature	5. Model	6. Prime Mover/Model	7. System Gen. Code	8. KW	9. Type Shelter	10. Weight
FU00504									

11. Reference Document	12. Manufacturer	13. Frequency (HZ)				14. Voltage							15. Phase				16. Number Operators	17. Source Of Values				18. Date
		DC	50	60	400	28	110	120	208	220	240	416	Single	3PH	DC	Other						

SUB SYSTEM

19. System Code	20. Line Number	21. Nomenclature	22. Model	23. NSN	24. Required			25. Type Voltage		26. System BTU		27. Value Source				28. Qty	29. Remarks
					Volts	Amps	Watts	AC	DC	Heating	Cooling	M	C	S	T		

Figure 1. System Inventory Form

Power Measurements Data Matrix

Power Measurement Load Configuration

Page ___ of ___

Date __/__/__

System _____

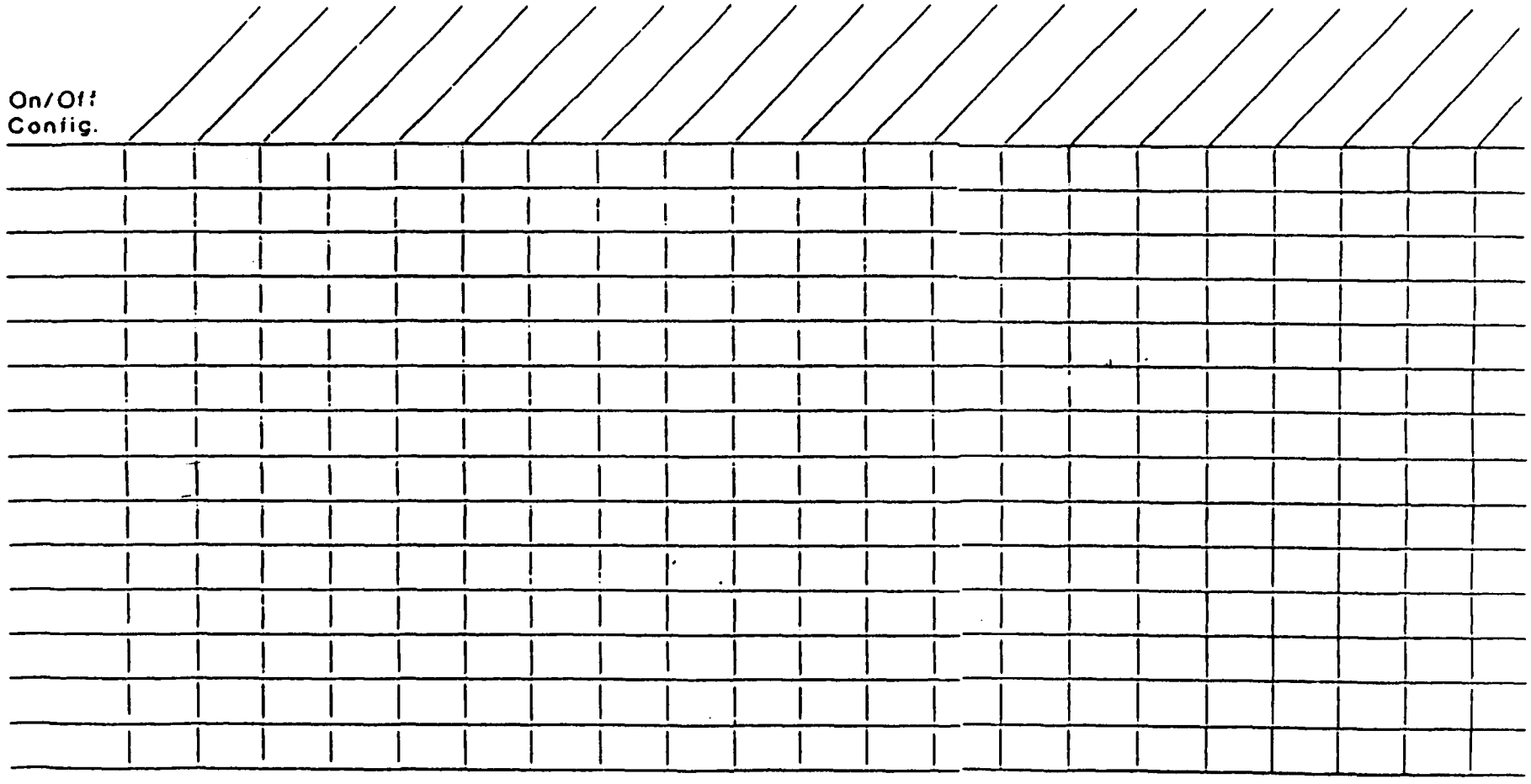

Figure 2. Power Measurement Load Configuration

Power Measurements Data Matrix

Page ___ of ___

Power Generator Performance Data

Date __/__/__

System _____

On/Off Config.	Phase A				Phase B				Phase C			
	V	A	W	PF	V	A	W	PF	V	A	W	PF

Figure 3. Power Generator Performance Data

INTRODUCTION

The information in this completed debriefing is supplemental to and becomes part of the unbundled system data file.

The data for this portion of the Air Conditioner Requirements Review will be obtained by a member of the TAP program Unbundling Team during an informal discussion with an assigned operator of the unbundled system. The following sections should be used to guide the discussion.

SYSTEM DESCRIPTION

1. Date:_____

2. System Unbundled: _____

3. Location: _____

4. Site Description: _____

_____

SYSTEM POWER REQUIREMENTS

5. What Type of Power Does the System Require? ____60Hz; ____DC;

____400Hz; Single Phase? ____120v; ____240v; Three Phase?

____208v; ____416v?

6. For DC Systems, What Equipment Requires the DC Power? _____

_____

7. For 400Hz Systems, What Equipment Requires the 400Hz Power? _____

_____

DEMOGRAPHICS

8. Briefer: _____

9. Briefee: _____ MOS: _____

10. Training: ____ School ____ OJT ____ When? _____

11. Length of Assignment to System: Years _____ Months _____

12. Field Exposure While Assigned: _____

Figure 4. Debriefing Format

_____

_____

MODES OF OPERATION

13. What are the System's Mode(s) of Operation?

_____

_____

14. How Many Operators Required For Each Mode?

15. Low _____

16. Moderate _____

17. High _____

18. Your Understanding of Low Intensity Operation. _____

_____

_____

19. Your Understanding of Mid Intensity Operation. _____

_____

_____

20. Your Understanding of High Intensity Operation. _____

_____

_____

21. What Is the Expected Duration for High Intensity Operation? _____

_____

_____

22. What Is the Longest Required Duration for High Intensity Operation

_____

_____

Figure 4. Debriefing Format (Continued)

23. Which of the Three Operational Levels Have You Operated the System? ____ Low ____ Mid ____ High

24. Do You Normally Operate the System With the Shelter Door Open ____ Or Closed ____?

NBC

25. Is the Shelter Equipped with Collective Protection for NBC (CBR) conditions? ____

26. How Well Does the Collective Protection System Work? _____

_____

_____

ENVIRONMENTAL CONTROL UNIT

27. Does the Shelter Have An ECU? ____ Yes __ No

28. ECU Nomenclature: _____

29. Model: _____

30. Heating: _____ BTU

31. Cooling: _____ BTU

32. How Often Do You Use the ECU? _____

_____

33. What Is Your Assessment Of the Interior Comfort When Your System Is Being Operated For Extended Periods During Hot Weather? _____

_____

34. What Is Your Assessment Of the Comfort When Your System Is Being Operated For Extended Periods During Cold Weather? _____

_____

_____

Figure 4. Debriefing Format (Continued)

35. Do You Think the ECU Adequately Maintains Proper Equipment Operating Temperatures?

36. During Hot Weather? _____

37. During Cold Weather? _____

38. How Would You Categorize Operation (Operator Interface) Of the ECU?

39. Easy ____

40. Difficult ____

41. Complex ____

42. What Problems Have You Experienced With the ECU? _____

43. 1. _____

44. 2. _____

45. 3. _____

46. What Other Comments Regarding the System, Its operation, Air Conditioning, Heating, Or Collective (NBC/CBR) Protection Would You Like To Note? _____

Figure 4. Debriefing Format (Continued)

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